PATENT SPECIFICATION

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375,515

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Complete Accepted: June 30, 1932.

COMPLETE SPECIFICATION.

Tail-less Aeroplane Constituted by a Three-element Wing.

I, JEAN FRÉDÉRIC GEORGES MARIE LÉON CHARPENTIER, a citizen of the French Republic, of 5, rue Tahère, Saint-Cloud (Seine et Oise), France, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The requirement for improved aerodynamic efficiency has led builders of flying machines to suppress substantially all the auxiliary parts thereof, retaining only the wing. The ideal flying machine consists, therefore, of a wing without any empennage or tail unit adapted to provide both the lifting force and stability in the longitudinal and transverse directions, and also directionally.

It is known that it is always possible to obtain longitudinal static stability in the case of a wing assumed to be flying alone, the moment coefficient of which for zero lifting power is indifferent ($Cm >< 0$), by disposing the centre of gravity at a suitable distance beneath the metacentre. This stability exists only for certain conditions of flight corresponding to a given position of the centre of gravity and a given power, and to these alone. But the operation of the controlling parts, which are supposed of necessity to be constituted solely by a portion of the surface of the wing, as required to obtain the desired height, causes by the modification of the whole or of part of the wing section, a modification in the original conditions of equilibrium, a new state of equilibrium being possible only by a modification in the position of the centre of gravity, which is practically impossible.

On the other hand it is necessary to damp the pitching motion, the differential equation of which:

$$I\frac{d^2\theta}{dt^2}+\frac{aVd\theta}{dt}+bv^2=c$$

includes coefficients a and b the values of which are mainly determined by the tail unit.

For the above reasons it is possible to conclude that a normal wing having a continuous horizontal outline and having neither an arrow shape, nor a dihedral, nor warping means, cannot fly without a tail plane or an equivalent device.

The object of my invention is to produce a flying machine of the type constituted solely by a three element wing, the central part of which has a constantly rearing moment coefficient for zero lifting power. This central part is of substantially greater chord than the two lateral parts.

According to my invention the magnitude of the surface area of the central element is substantially equal to that of the total surface area of the outer elements while the leading edges of the three elements are substantially in alinement so as to provide in horizontal projection a continuous outline.

This relative arrangement of the parts formed of suitable wing sections allows the aerodynamic resultant on the whole wing to have a lift component the law of displacement of which with varying angles of attack ensures steady equilibrium for different flying attitudes.

The machine may be provided with vertical drag surfaces or fins, say to the rear of the central part.

The central part of the wing provides all or the major part of the longitudinal static stability together with the dynamic stability owing to the position of its centre of gravity, its great depth with reference to the lateral parts, and the absolute value of its moment coefficient for zero lifting power, which value provides its preponderancy over the moment coefficient of the lateral parts.

This moment coefficient for zero lifting power which provides a rearing torque produces stability of the aeroplane flying with its underside lowermost.

In order that the moment coefficient for zero lifting power may constantly provide a rearing torque the central part may have a trailing edge flap adapted to be raised but never lowered.

The considerable chord of the central part allows the coefficient a of the damping torque $av\frac{d\theta}{dt}$ of the pitching equation

to be determined, which ensures a good predetermined damping $M=\frac{av}{I}$ depending on the longitudinal moment of inertia I of the machine.

The lateral parts are provided with horizontal elevators which are constituted by flaps disposed along their trailing and leading edges. The trailing flaps may control as usual the movements of elevation by causing the machine to fly downwards when they are deflected downwards and to fly upwards when they are deflected upwards, their movements being in this case controlled in parallel. The particular wing section chosen for the lateral parts is unimportant and is determined for instance by the conditions of use.

The lateral parts of the wing are adapted to increase, owing to their arrangement on either side of the central part, the aspect ratio thereof (i.e. the ratio between the square of the span and the surface area $\lambda=\frac{L^2}{S}\Big]$.

They also contribute to the supporting properties of the machine under good aerodynamic conditions (as they may be given a great aspect ratio), and also to the dynamic stability, and in certain cases to the longitudinal static stability.

The transversal movements are controlled:

a) either by the simultaneous and opposite action of the elevation flaps the movements of which are conjugated and obtained independently of their elevational movement;

b) or by the action of other flaps disposed further than the elevating flaps from the longitudinal axis of inertia.

The lower central dihedral of the machine contributes to the directional steadiness of the machine, as it causes, when the machine is moved out of its position of equilibrium, an increase in the drag (Δcx) for the side which is moving forwards, the moment of which with reference to the centre of gravity of the machine provides stabilisation.

But the stabilising action of the dihedral is insufficient. Therefore, as hereinbefore stated, the machine may be provided with one or more stationary drag surfaces or fins parallel to the plane of symmetry.

If required the control as to direction may be obtained by flaps disposed on either side of the edges of the outer end of the lateral parts of the machine, or by rudders formed at the rear of the drag surfaces.

The machine in vertical projection has an upper dihedral and a lower dihedral in its plane of symmetry. The lower marked dihedral of the central part forms a hull bottom which allows the machine to be constructed as a marine aeroplane, or, with the addition of one or more steps, as a seaplane. It is possible to give the central part seagoing properties allowing it to float even in heavy weather. If the machine is not able to take off, its floating powers may be increased by letting go the lateral parts of the machine.

Lastly in the machine according to my invention, the distribution of the masses is such as to provide as far as possible a uniform distribution, whereby each elementary surface supports itself during horizontal rectilinear flight. This condition being satisfied for any two adjacent points, it is apparent that all flexional stresses may be prevented in the wing beam, which results in considerable safety.

This distribution of the masses along the line of span gives the machine a small longitudinal momentum of inertia, which is of interest for calculating the damping of the pitching oscillations

$$M=\frac{av}{I}$$

A third advantage of this distribution of the load along the line of span is to allow of permanent centering of the machine whether loaded or not.

Thus the pilot may always, however large the machine may be, fly alone without any ballast. It is possible in fact to distribute the loads symmetrically with reference to the transversal vertical plane containing the centre of gravity, so that the latter is always at the same point whatever the total load may be.

The following description and appended drawings show, solely by way of example, a constructional form of machine according to the invention.

Figure 1 is a plan view of the machine.

Figure 2 is a front view thereof.

Figures 3, 4 and 5 show flaps functioning as elevators.

Figures 6, 7, 8, 9 and 10 show diagrammatically the positions of the flaps for lateral balancing corresponding to the case where the planes for transversal control consist of parts of the elevating flaps.

Figures 11 and 12 show the positions of the flaps for steering.

Figures 13, 14, 15 illustrate a constructional arrangement of the flap control.

The machine comprises a central part 1 and two lateral parts 2 and 3 (Figure 1).

In the central part are the navigation cabin, the pilot house, the machine rooms,

etc, . . and also the passenger's cabin which may extend into the lateral parts 2 and 3 which contain the luggage room, the postal or the like freight and the tanks. Obviously the fuel tanks are placed as far as possible from the inhabited parts.

To the rear of the central part 1 is a flap 4 which is quite independent of the other controls and may pivot round the spindle 5 perpendicular to the plane of symmetry of the aeroplane and is actuated by independent control means which allows the pilot to modify, by alteration of the camber of the central portion, the coefficient of stability of the aircraft for a given position of the centre of gravity, or to retain a given value of the coefficient in spite of modifications in the position of the centre of gravity, as for instance in the case of a start without load, or, during flight, for compensating for the change in trim due to consumption of fuel.

On the leading edges of the lateral parts are flaps 6 and 7 and on the trailing edges flaps 8 and 9.

These flaps produce vertical evolutions by rotary movements as shown diagrammatically in Figures 3, 4 and 5, which show how these flaps, starting from positions corresponding to the conditions of equilibrium for horizontal rectilinear flight are inclined for upward or downward flight.

Figure 3 shows the flaps 7 and 9 in their positions corresponding to the original shape of the outline determined for the lateral parts during horizontal rectilinear flight, the flaps 6 and 8 having, of course, corresponding positions. To obtain upward flight, the trailing flaps 8 and 9 are lowered as shown in Figure 4, the leading flaps 6 and 7 remaining in their position for horizontal flight. For changing into downward flight, the trailing flaps are brought into their original position (Figure 3) and the flaps 6 and 7 are lowered as shown in Figure 5. It will thus be apparent that for vertical evolutions, the centre of gravity remaining in the same vertical plane, either the leading flaps or the trailing flaps are moved from normal position, but never both simultaneously.

Figures 13, 14, 15 show, by way of example, a control device whereby these movements may be executed. A balance beam 12 is guided in any manner not shown, so as to be able to move in a plane parallel to the plane of symmetry of the aeroplane. This beam is connected by two small rods 13 and 14 to the flaps 6 and 8; the latter are pivotally secured to the adjacent aeroplane parts at their lower edges by means of a hinge, the small rods 13, 14 being pivotally connected near their upper edge. The balance beam 12 is connected to cables 15 and 16 passing over pulleys 17 and leading to control devices in the pilot's cabin. This balance beam 12 may abut at its ends against stationary cleats 18 and 19 placed respectively on opposite sides thereof. The operation is as follows: in the position for horizontal flight (Figure 6) the two flaps bear against the adjacent aeroplane parts and the balance beam 12 rests at both ends against the cleats 18 and 19.

To change from horizontal flight to upward flight, the pilot should, as stated hereinabove, lower the trailing flap without modifying the position of the forward flap 6; to this end he pulls the cable 15, and the balance beam pivots about the cleat 19 and through the medium of the small rod 14 tilts the flap 8, the flap 6 remaining stationary as shown in Figure 7. For downward flight the pilot on the contrary pulls the cable 16, which first returns the parts into the positions shown in Figure 6; as he pulls further upon the cable 16 he rocks the balance beam about the other cleat 18 and the flap 6 moves downwards, whilst the flap 8 remains stationary.

The trailing flap 8 may be in two parts 8, 8^1 to which different inclinations are given so as to have a wing outline having an improved continuity when deformed as shown in Figure 14. The part 8^1 alone may also in certain cases be moved upwards or downwards, as shown, for instance, in Figure 15, which shows warping produced only by the secondary flap 8^1 for the purpose of restoring transversal equilibrium for rectilinear horizontal flight.

Transversal control may be produced either:

a) By the use of trailing flaps 8 and 9 as horizontal rudders, to which end they co-operate for transversal control by adding their effects. This co-operation, however, requires that the flaps 8 and 9 be hinged for movement in opposite directions, and be operated by mechanism different from that illustrated in Figures 13, 14 and 15 which only provides for movement of one flap at a time.

b) By a fraction 8^1 of the surface of the flaps, which may be actuated independently of the part 8.

The diagrammatical Figures 6, 7, 8, 9 and 10 illustrate the flap movements for transversal control under different flight conditions.

Figure 6 shows the positions of the flaps for horizontal rectilinear flight.

Figures 7 and 8 show the positions of the flaps 6, 8 and 8^1 for upward flight.

Figure 9 and 10 show the same for downward flight.

c) By flaps 7^1 and 9^1 different from and independent of the flaps forming horizontal rudders, which alternative construction is, for the sake of convenience, illustrated in one half only of Figure 1.

In the three cases the operations necessary for obtaining transversal control are obtained through a system absolutely independent of that controlling the height.

For steering, provision is made for double warping of the end of the wing nearer to the centre of curvature of the aeroplane's path, by the lowering of one or more of the flaps at the leading edge and the raising of one or more of the flaps at the trailing edge as shown in Figure 11, in which are shown the positions given to the extreme flaps 32, 33 of the left lateral part for making the aeroplane follow a curve about a point to the left of Figure 1.

This double warping changes the direction of the wing chord which takes up the position shown in dotted lines in Figure 11 and thus produces two co-operating effects producing the desired change of direction; in the first place the thrust is reduced i.e. a negative thrust inclines the machine towards the inside of the curve, and on the other hand the drag is increased which gives a fulcrum to the aeroplane on this side.

The flaps 32, 32^1, 33, 33^1 which are to serve for steering may be interconnected, for instance by means of a suitable link arrangement controlled by any suitable means.

A vertical rudder 10 attached to a fixed fin 11 may also if required be used together with the flaps for steering, but it is not necessary in all cases.

The dihedral shape given to the aeroplane allows it to be provided with a special landing gear of particular interest, consisting mainly of a central device 23 (Figure 2) formed, for instance, by twin wheels disposed in the plane of symmetry of the aeroplane, and, in order to reduce the stresses produced by the weight of the overhung motors, by two other devices 24 and 25 disposed laterally beneath the motors. Thus when the aeroplane travels over the ground, it rests on three landing devices, so that the plane flexional stresses acting on the framework are greatly reduced.

In order to avoid the drag produced by these landing devices, the lateral devices 24 and 25 may, by means of suitable mechanism, be caused to disappear inside the aeroplane when the latter is flying.

If the aeroplane has to alight on water after the manner of a seaplane, the central wheels do not form an obstacle and the lateral wheels 24 and 25 co-operate to increase the stability.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A tail-less aeroplane of the type comprising a central element having a wing section ensuring stability and two outer wing elements of smaller chord separated by a plane of discontinuity from the former, wherein the surface area of the central element is substantially equal to that of the total surface area of the outer elements while the leading edges of the three parts are substantially in alignment.

2. A tail-less aeroplane as claimed in claim 1, wherein the central element is provided with a trailing flap which cannot be lowered with reference to its inoperative position for which its upper surface forms part of the upper surface of the central element, the arrangement being such that the total moment coefficient at zero lift of the aeroplane provides a rearing motion for any flying attitude.

3. A tail-less aeroplane of the type disclosed substantially as described with reference to and as illustrated in the accompanying drawings.

Dated this 1st day of June, 1931.

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Fig. 1

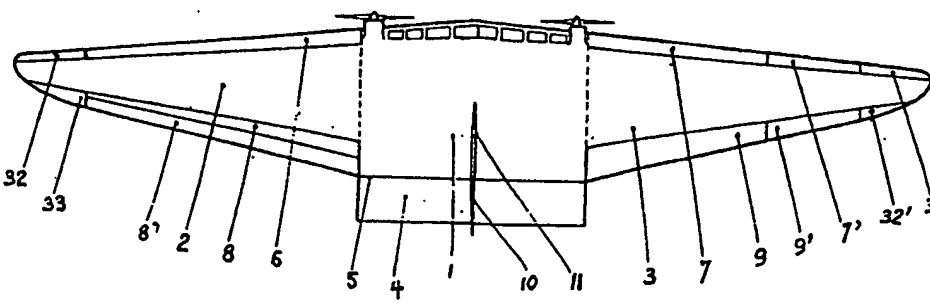


Fig. 2

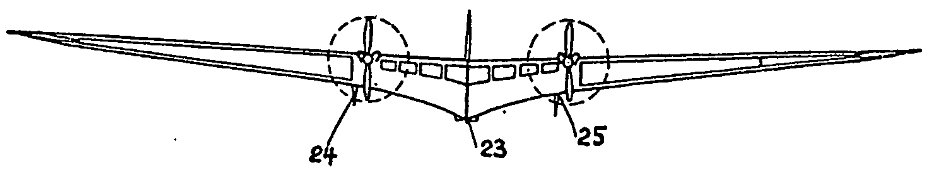


Fig. 3

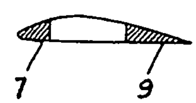


Fig 4

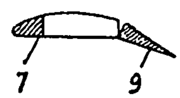


Fig. 5

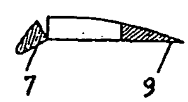


Fig. 7

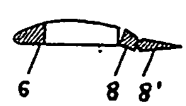


Fig. 8

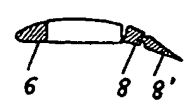


Fig. 6

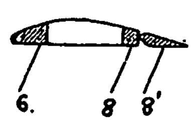


Fig. 9

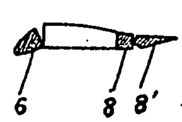


Fig. 10

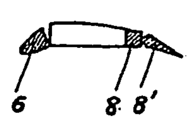


Fig. 11

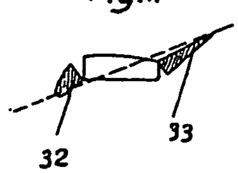
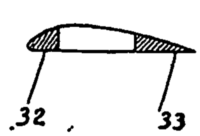


Fig. 12



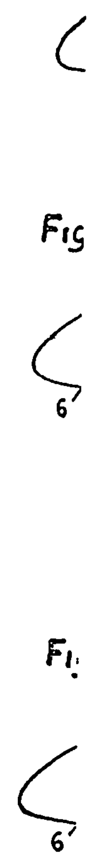


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Fig. 13

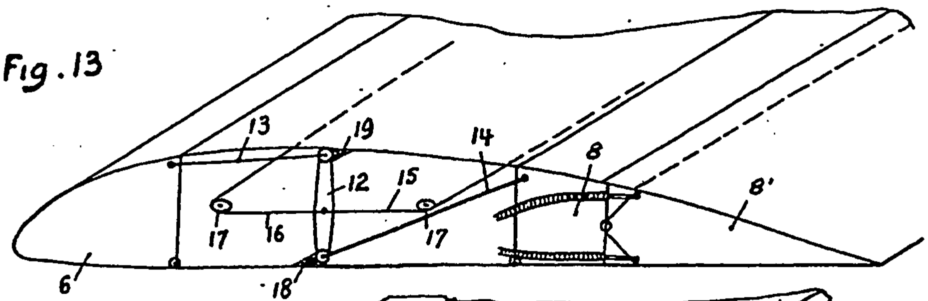


Fig. 14

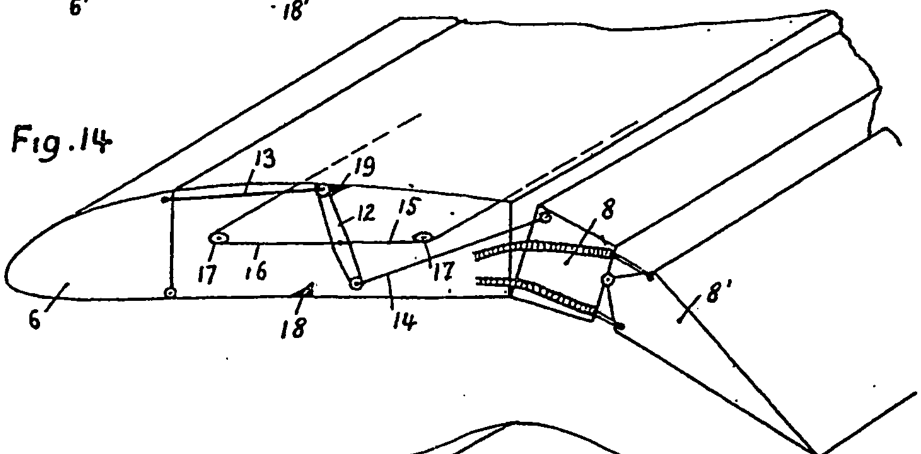
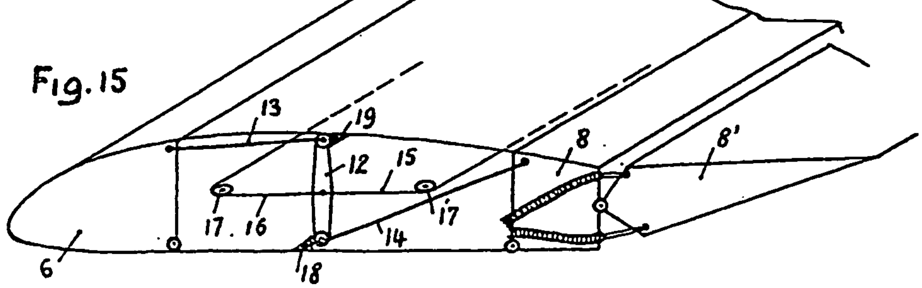


Fig. 15



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375,515 COMPLETE SPECIFICATION

2 SHEETS

SHEET 1

Fig. 1

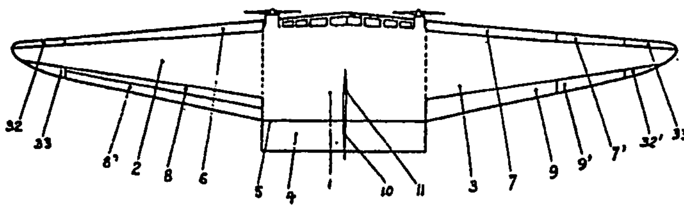


Fig. 2

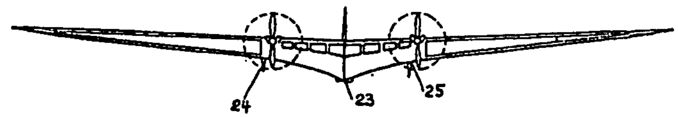


Fig. 3

Fig 4

Fig. 5

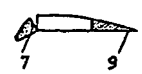


Fig. 6

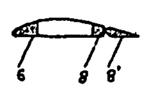


Fig. 7

Fig. 8

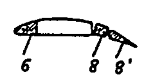


Fig. 9

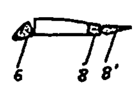


Fig. 10

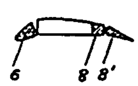


Fig. 11

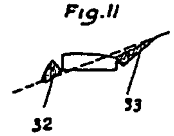
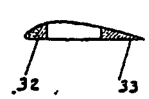


Fig. 12



SHEET 2

Fig. 13

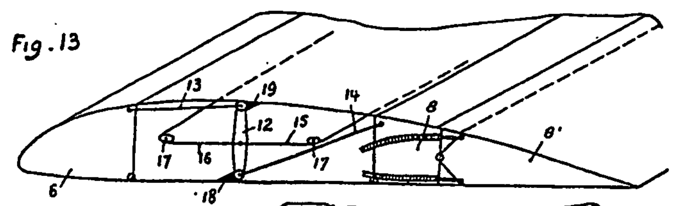


Fig. 14

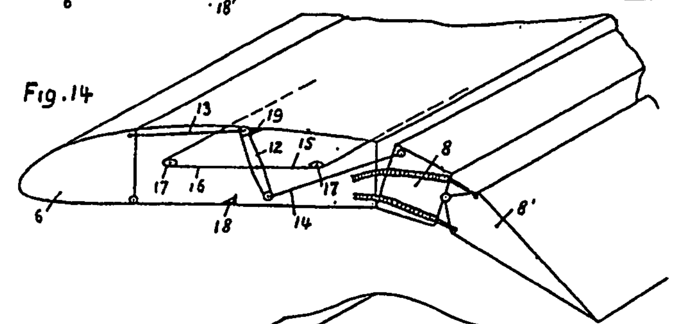
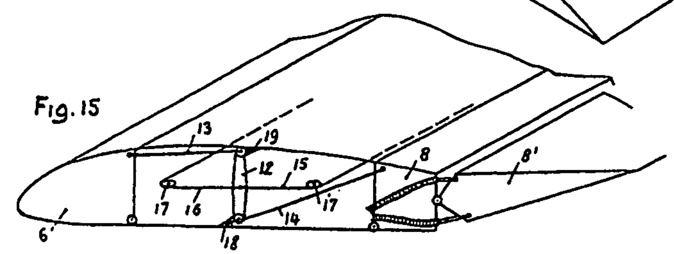


Fig. 15



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